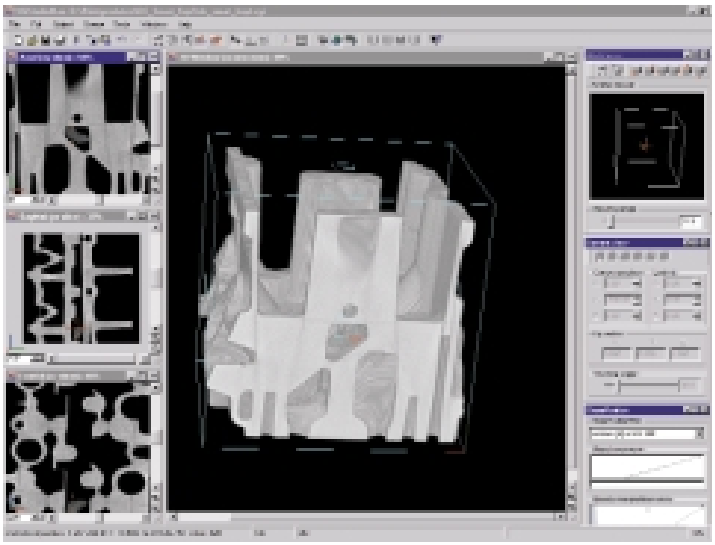
DAIMLERCHRYSLER

Milestone in nondestructive testing (NDT):

DaimlerChrysler creates 3D visualizations with Fujitsu Siemens Computers* Itanium™ platform



The highest quality requirements and continual progress in motor vehicle development mean that materials and production processes are constantly faced with more demanding challenges. Even the smallest weaknesses and irregularities in workpieces and materials must be examined. At DaimlerChrysler, the Production and Materials Technology Center in Untertürkheim tackles this gargantuan task with countless physical and chemical testing methods. With the help of state-of-the-art junction-type detectors and a system consisting of a high performance cluster and workstations from Fujitsu Siemens Computers*, the computer tomography technology known from medicine can now be used to provide fascinating images of the inside of complicated workpieces. The specialists in Untertürkheim have been operating the most modern and comprehensive system of its kind in Europe since the beginning of 2001.

A journey through steel

X-ray testing is now a standard instrument in materials testing. Up until now, however, it has normally only been possible to examine individual areas inside the workpiece. Gerhard Maier, director of physical testing procedures at DaimlerChrysler: “Until now, we could only either scan a complete workpiece without location information or prepare individual sectional images. We had to know exactly where to look. The new system captures the entire object with its geometry and its structures. It is now possible to ‘travel through the workpiece’ during testing to locate the smallest of faults. We can even create videos of these virtual exploration missions.”

The object is scanned with an extremely fine scanning raster in order to ensure that even the smallest irregularities are located. The raster spacing varies between 10 and 300 thousandths of a millimeter depending on the objective of the test, with each point in this grid supplying a measurement value. The workpieces and samples to be tested generally range in size from a few millimeters to 0.8 m, for example for cylinder heads. This means that each test generates enormous volumes of data that have to be converted into visible results as quickly and efficiently as possible.

Flexibility is the key

The NDT specialists in Untertürkheim provide a wide range of services in the group, ranging from material testing for developers all the way to quality assurance. The department's customers include development departments and production divisions, and work has even been completed for suppliers in special cases. Computer tomography can be used to test nearly any material, from rubber and ceramics to aluminum and steel all the way to composite materials. A 225 kV microfocus X-ray tube with an 8-10 micrometer focal spot ensures maximum resolution. A 450 kV X-ray source with an 0.8 mm focal spot is used for thicker parts. This source is powerful enough to scan aluminum pieces over 200 cm thick, or steel pieces over 10 cm thick.

Objects up to 40 cm in length can be scanned in a single pass. Larger objects are scanned in multiple scanning passes, the results of which are then compiled by the computer. Each individual scan yields between five and ten gigabytes of raw data in 20 to 40 minutes. The reconstruction calculation converts this data into three-dimensional image data (voxels) for the entire object. The 800 MHz Intel® Itanium™ double-processor workstation "Celsius* 880" takes the user "into" the object, allowing casting sand remnants or inclusions to be located while "flying through" the solid material.

Advances in computer technology allow new quality in measurement

This new technology was made possible through advances in the memory addressing capacity and processing speed of the workstation. The visualization data for a single workpiece can easily amount to five gigabytes or more. Conventional 32-bit systems with a maximum memory addressing capacity of two or four gigabytes could not handle these data volumes. Dr. Bernd Frühauf, IT representative for the CT system at DaimlerChrysler explains: "Practically all of the measured volume elements must be loaded into RAM in order to display the 3D X-ray model. If they aren't, the analysis is far too slow. This makes the 16 gigabytes of RAM in the Celsius workstation absolutely necessary – without it, a system of this scope would not be practical. 64-bit technology has made it possible to process such enormous volumes of data for the first time."

High resolution – a curse or a blessing?

The microfocus X-ray tube used in the system can capture details as small as approximately eight micrometers. Even though this is far smaller than a human hair, the specialists at DaimlerChrysler are not splitting hairs – it is crucial that even the smallest blowholes, inclusions and hairline cracks are identified in order to ensure the quality and safety of all components. The possibility of magnifying workpieces up to 50 times is especially helpful when working with very small components. The high resolution is also the reason for the enormous data volumes, as every cubic millimeter in the object results in several megabytes of data. The data for a tiny M3 screw would not fit into the 128 MB of RAM of a modern desktop PC.

The first 64-bit processors were already developed many years ago to process large volumes of data. Due to the fact that they have a far greater addressing capacity than 32-bit systems, such processors are able to access large amounts of RAM directly. The Intel® Itanium™ processor provides system designers with 44 bits of physical memory addressing, theoretically allowing access to up to 16 terabytes of memory.

But there are a number of other factors that also play a role in the efficient management of large volumes of data – it is not only the addressing capacity, but also the speed of the provision and transfer of data that is crucial in this. With its three-level internal cache and its EPIC (Explicit Parallel Instruction Computing) technology, this new processor generation can achieve a very high level of continual data throughput. Each of the two CPUs in the Celsius workstation accesses the external L3 cache at a speed of 12.8 gigabytes per second. The data flows from this cache directly to the floating point register or the internal caches in a continuous stream. Both Itanium processors in the workstation can process 2.1 gigabytes per second each from the RAM, or together over 4 gigabytes per second. The actual capacity depends on the type and number of memory banks in the system and their addressing logic – which means that there is much room for optimization.

Large amounts of RAM have also become more economical due to the fact that advances in semiconductor technology have driven memory prices down. While the 4 gigabyte limit of 32-bit systems was unattainable for many users a few years ago because of the high costs, every larger departmental server today can be fitted with this much RAM. What is more practical than exploiting this situation for advanced applications? Workstations with 16 gigabytes of RAM are certainly still the exception at this time, but visualization, media processing and continual advancements in measurement technology require more and more memory and more powerful computing platforms.

The gigabyte mover – special software under Linux*

Volume Graphics already brought a commercial 64-bit version of its visualization application "VG Studio" onto the market under Linux* at the beginning of 2001. This made the selection of the 64-bit operating system easy for DaimlerChrysler. Initially, there were a few stability problems with a previous version of the kernel, but now the application runs reliably under the 64-bit version of RedHat* Linux 2.4. The software has been in operation in Untertürkheim since the beginning of 2001, first in testing, and now in routine productive use.

Initially, the five to ten gigabytes of raw data from the junction-type detector only indicate the intensity of the X-ray radiation after passing through the entire object. This value is the result of all losses in intensity as the radiation passes through the workpiece. The measurement must be repeated at as many angles as possible in order to obtain the required data. Next comes the complicated reconstruction of the effect of each individual volume element, which is completed by means of a high-performance Fujitsu Siemens Computers cluster in the Untertürkheim laboratory. The 64 1 GHz Intel® Pentium® III processors with their theoretical top performance of over seven teraflops still require up to four hours for the reconstruction, depending on the complexity. This cluster is operated practically 24 hours a day in order to be able to process the measurements from the previous day overnight.

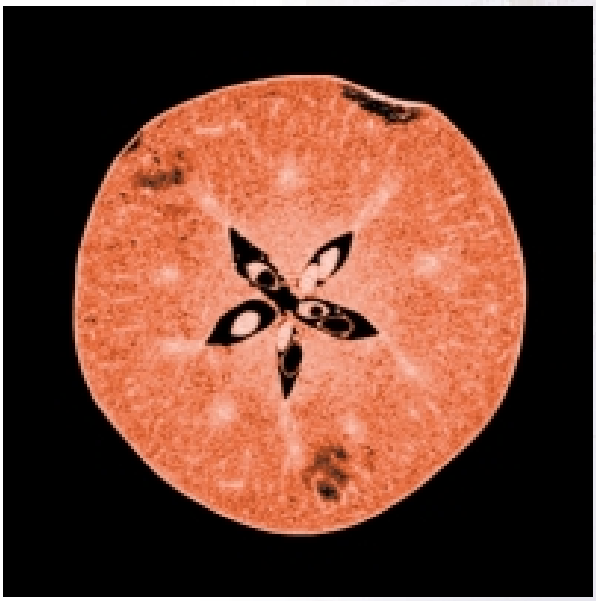
For the visualization, the software assigns each volume unit a specific opacity, or degree of transparency. This allows the user to move about freely in the entire data set. In contrast to simple surface models that are created on the basis of splat or tesseral algorithms (color point process or volume segmentation), this visualization can also display parts behind other parts in an intuitively comprehensible manner – a considerable advantage for extensive data sets.

Productive pilot project

DaimlerChrysler's decision to use technology from its partner Fujitsu Siemens Computers was made pragmatically. As the companies have been working together well for a number of years, Fujitsu Siemens Computers is trusted as an established partner with solid technology. In addition, the Intel® Itanium™ processor was the only 64-bit platform that met all of the department's requirements for software availability and long-term perspectives. Fujitsu Siemens Computers was able to provide a pilot system for the 64-bit Celsius workstation at the beginning of 2001, which began productive measurement operations immediately after delivery. Since then, Fujitsu Siemens Computers has been keeping the workstation up to date with the latest technological developments, for example with the latest CPU chips.

In spite of this, the operation of this computer is anything but routine. Hansjörg Jakobi, responsible for the test operation of the CT system at DaimlerChrysler: "Computer tomography continually provides new knowledge that often has a direct effect on the development of the component as a result of its fantastic detail accuracy and resolution." And time is working for DaimlerChrysler and its employees – because the IA-64 processors are getting better and faster as time goes on. The system will be further optimized in the future, for example through the tighter and faster coupling of the cluster and the visualization workstation. As 3 employees currently service the system, plans are already in place for the parallel use of the system by multiple users.

In the future, the powerful CT system will also be used for a new area of application: reverse engineering. The X-ray system can be used to take a look inside of finished components from suppliers or other manufacturers and to analyze components exactly without damaging them. This will allow components to be evaluated more thoroughly and will also allow the quality and function of complex parts to be checked more quickly.

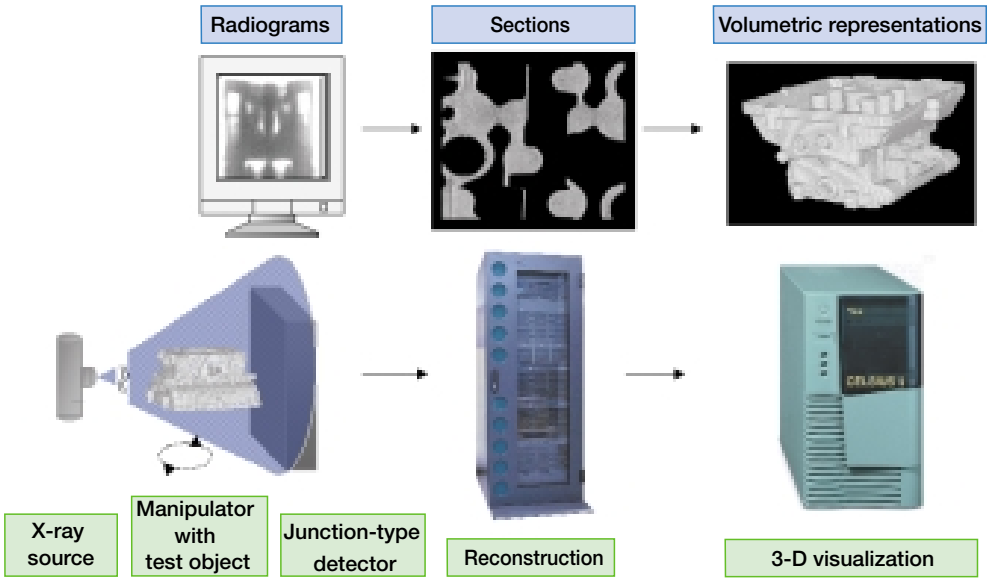


Ever higher and farther?

As the Intel® Itanium™ processor is only the first in a series of announced developments, system architects and chip designers will be able to continually increase the performance of their systems in the coming months and years. Experience has shown that improvements in compiler technology and software optimizations alone at the beginning of a new generation of processors result in considerable performance gains. The next versions of Intel's 64-bit CPU and the system design can also be expected to bring significant advances for the user. The development of the IA-64 over the next few years is certain to yield a great deal of binary-compatible performance potential. And each of these improvements means direct productivity increases – in other words the number of objects examined per day – for measurement technology users. The scan that takes 30 minutes today can potentially be completed during a telephone call in the future. The foundation has been laid. Because no computer could possibly be too fast.

Brief technical description:

The components to be examined are rotated in an X-ray system in as many as 1440 steps by means of high-precision manipulators, whereby 1000 times 1000 measurement points are recorded by a junction-type detector during each rotation step. A high-performance cluster of 64 Intel® Pentium® processors from Fujitsu Siemens Computers reconstructs every volume element of the entire component from this data. These are then converted into high-resolution visualizations for 3D analysis on a "Celsius 880" workstation with two Itanium™ 800 MHz processors and 16 GB RAM.



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